

# SEX RATIO ANALYSIS IN *ERIPHIA GONAGRA* (DECAPODA, XANTHIDAE)

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## ABSTRACT

The sex ratio of *Eriphia gonagra* (Fabricius, 1781) by estimating the proportions of both sexes within a population was determined and discussed with other brachyuran species. Crabs were monthly collected from January to December of 1993, 1994, 1996 and 1997 at a rocky shore of Praia Grande, Ubatuba, São Paulo, Brazil. Sex ratio was 0.86:1 in 1993; 1.08:1 in 1994 and, 0.90:1 in 1996 and 1997. In each year, significant differences among months or size classes were absent in most cases ( $p > 0.05$ ). This may be an outcome of unbiased sampling, which is expected in data drawn from populations inhabiting discrete areas such as rocky shores. It is suggested that overall sex ratio for brachyurans tends to 1:1. Departures from this ratio may be related to certain sampling procedures and to selecting inadequate sampling areas.

KEYWORDS. Sex ratio, *Eriphia*, Brachyura, Xanthidae.

## INTRODUCTION

Some authors reported that sex ratio is genetically controlled in several species (CREW, 1937; MAYR, 1939). In studies regarding population dynamics, sex ratio has been estimated by comparing the proportion of males and females in samples obtained from a given population (HALEY, 1979). KOLMAN (1960) presents a model in which the mechanism described by FISHER (1930) regarding natural selection of sex ratio is quantified and further extended. This shows how sex ratio is adjusted to balance parental costs of producing males and females, a mechanism that may affect the sex ratio average but not its variance.

Therefore, sex ratio is generally about 1:1 in animals with sexual reproduction. According to WILSON & PIANKA (1963), this pattern is favored by natural selection but alterations usually emerge after a period of parental care.

WENNER (1972) described four patterns of sex ratio variation as a function of size in marine crustaceans and provided some possible explanations for the "anomalous pattern" based on sexual reversion, sex-related longevity, migratory patterns, mortality and growth rate.

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Concerning brachyuran crabs a number of papers had focused sex ratio. BROEKHUYSEN (1936), GIESEL (1972), SWARTZ (1976), CONDE & DIAZ (1989) and SPIVAK *et al.* (1991) are noteworthy examples. The present purpose is to determine the sex ratio in *Eriphia gonagra* (Fabricius, 1781) by comparing relative proportion of males and females within a single population and compare these results with similar data obtained for other brachyurans.

### MATERIAL AND METHODS

The specimens examined were obtained during monthly collections from January to December of 1993, 1994, 1996 and 1997 at a rocky shore of Praia Grande (23°28'02"S - 45°03'35"W), Ubatuba, São Paulo, Brazil.

Hand-collections were carried out covering all shore's extension (about 1200 m<sup>2</sup>) during low tides. Crabs were separated in individual plastic bags, frozen and transported to the laboratory. Maximum carapace width (CW) of all crabs was recorded. Individuals were counted, sexed, distributed in size classes using the STURGES' formula (1926) and discarded. For smallest specimens, sex was determined with a dissecting microscope. For comparisons among brachyuran species, literature coverage includes not only papers focusing sex ratio itself, but also accounts on population structure and reproductive biology from which the overall sex ratio of some species was drawn.

Qui-square tests were performed to detect differences between number of males and females along months and across the size range of *E. gonagra* for the whole 4-yr sampling period. Qui-square tests were also carried out to test departures from the 1:1 proportion in other brachyurans (SOKAL & ROHLF, 1979).

### RESULTS

Individuals were distributed in eleven 4.2 mm size classes from 4.2 to 50.2 mm CW. Along the sampling period, a total of 2531 specimens (1221 males and 1310 females) was obtained. This represents a 0.93:1 sex ratio favoring females but lacking statistical significance ( $p>0.05$ ) (tab. 1). Overall sex ratios for 1993, 1994 are 0.86:1 and 1.08:1, respectively. For 1996 and 1997, the sex ratio was 0.90:1. In a temporal analysis, significant deviations were only detected in February 1993 and May, June 1996. In the case of size related deviations, significant differences ( $p<0.05$ ) were found in three months. In 1996 and 1997 differences were detected in only one size class (fig. 1).

### DISCUSSION

In *E. gonagra*, overall sex ratio in 1993, 1994, 1996 and 1997 does not significantly differ from the 1:1 proportion ( $p>0.05$ ). This fact corroborates FISHER's (1930) and KOLMAN's (1960) theories, showing that this ratio is related to the fact that parental energetic costs for producing males and females is the same, thus favoring equal proportions of both sexes. This fact suggests that rates of recruitment and mortality are not sex-dependent what would promote the equilibrium of population structure.

Overall sex ratio as a function of size in *E. gonagra* during the entire 4-yr study period do not evidence statistical differences, but slight numerical departures from the 1:1 proportion were observed. This indicates that, as pointed out by WILSON & PIANKA (1963), biotic and abiotic factors, such as environmental pressure, food availability, habitat partitioning and differential behavior, may also play a role. In the case of temporal analysis, deviations from the 1:1 proportion are even scater with the expected pattern always prevailing.

Table 1. Sex ratio comparison of *Eriphia gonagra* with other among brachyurans species. M, males; F, females; T, total; SR, sex ratio; Ref, references: 1, ABELLÓ (1989); 2, ABELLÓ & MACPHERSON (1989); 3, ALCÁNTARA-FILHO (1978); 4, CONDE & DIAZ (1989); 5, DIAZ & CONDE (1989); 6, FURTADO-OGAWA (1972); 7, FURTADO-OGAWA (1977); 8, LUNARDON-BRANCO & BRANCO (1993); 9, MANTELATTO *et al.* (1995); 10, NEGREIROS-FRANZOZO *et al.* (1994); 11, OMORI *et al.* (1997); 12, RAZ-GUZMAN *et al.* (1986); 13, SANTOS *et al.* (1995); 14, SNOWDEN *et al.* (1991); 15, SPIVAK *et al.* (1991); 16, SUMPTON (1990); 17, SWARTZ (1976); 18, TSUCHIDA & WATANABE (1997); 19, TROTT (1998); 20, VANNINI & GHERARDI (1988; \*  $p < 0.05$ ; <sup>ns</sup> non significant).

Family / Species	M	F	T	SR	Ref
<b>Calappidae</b>					
<i>Hepatus pudibundus</i> (Herbst, 1785)	32	110	142	0.29 : 1 *	8
	167	238	405	0.70 : 1 *	9
<b>Grapsidae</b>					
<i>Aratus pisonii</i> (H. Milne Edwards, 1837)	1178	1894	3072	0.62 : 1 *	4
	2675	3480	6155	0.77 : 1 *	5
<i>Helice japonica</i> Sakai & Yatsuzuca, 1979	1223	1120	2343	1.09 : 1 <sup>ns</sup>	11
<i>H. tridens</i> De Haan, 1835	875	807	1682	1.08 : 1 <sup>ns</sup>	11
<i>Pachygrapsus transversus</i> (Gibbes, 1850)	410	388	798	1.06 : 1 <sup>ns</sup>	7
<i>Plagusia dentipes</i> De Haan, 1835	659	616	1275	1.07 : 1 <sup>ns</sup>	18
<b>Majidae</b>					
<i>Epialtus brasiliensis</i> Dana, 1852	128	114	242	1.12 : 1 <sup>ns</sup>	10
<b>Ocypodidae</b>					
<i>Ilyoplax stevensi</i> (Kemp, 1919)	770	765	1535	1.01 : 1 <sup>ns</sup>	14
<i>Ocypode gaudichaudii</i> H. Milne Edwards & Lucas, 1843	204	175	379	1.16 : 1 <sup>ns</sup>	19
<i>Uca uruguayensis</i> Nobili, 1901	822	488	1310	1.68 : 1 *	15
<i>Ucides cordatus</i> (Linnaeus, 1763)	796	1092	1888	0.73 : 1 *	3
<b>Portunidae</b>					
<i>Arenaeus cribrarius</i> (Lamarck, 1818)	80	43	123	1.86 : 1 *	8
<i>Bathynectes piperitus</i> Manning & Holthuis, 1981	3196	2215	5411	1.44 : 1 *	2
<i>Callinectes danae</i> Smith, 1869	203	437	640	0.46 : 1 *	8
<i>C. ornatus</i> Ordway, 1863	262	203	465	1.29 : 1 *	8
<i>C. sapidus</i> Rathbun, 1896	57	24	81	2.4 : 1 *	12
<i>C. similis</i> Williams, 1966	37	15	52	2.5 : 1 *	12
<i>Charybdis natator</i> (Herbst, 1794)	694	381	1075	1.82 : 1 *	16
<i>Macropipus tuberculatus</i> (Roux, 1930)	1048	807	1855	1.30 : 1 *	1
<i>Portunus spinimanus</i> Latreille, 1819	101	178	279	0.57 : 1 *	13
<b>Xanthidae</b>					
<i>Eriphia gonagra</i> (Fabricius, 1781)	1221	1310	2531	0.93 : 1 <sup>ns</sup>	
<i>E. smithi</i> Macleay, 1838	227	595	822	0.38 : 1 *	20
<i>Eurypanopeus abbreviatus</i> (Stimpson, 1860)	97	77	174	1.26 : 1 <sup>ns</sup>	6
<i>Neopanope sayi</i> (Smith, 1869)	1149	1286	2435	0.89 : 1 *	17
<i>N. texana</i> (Stimpson, 1859)	133	88	221	0.40 : 1 *	12
<i>Panopeus herbstii</i> H. Milne Edwards, 1834	330	293	623	1.13 : 1 <sup>ns</sup>	6

The equal proportions is not a rule for all brachyuran families, since in some of those there is high variability. A number of different explanations were raised to justify results and, a common pattern for all brachyurans is lacking. According to WENNER (1972), this difficulty is closely related to differential distribution of males and females within the population.

In the Calappidae, significant differences were found in *Hepatus pudibundus* (Herbst, 1785), which can be a result of certain reproductive features of this species.

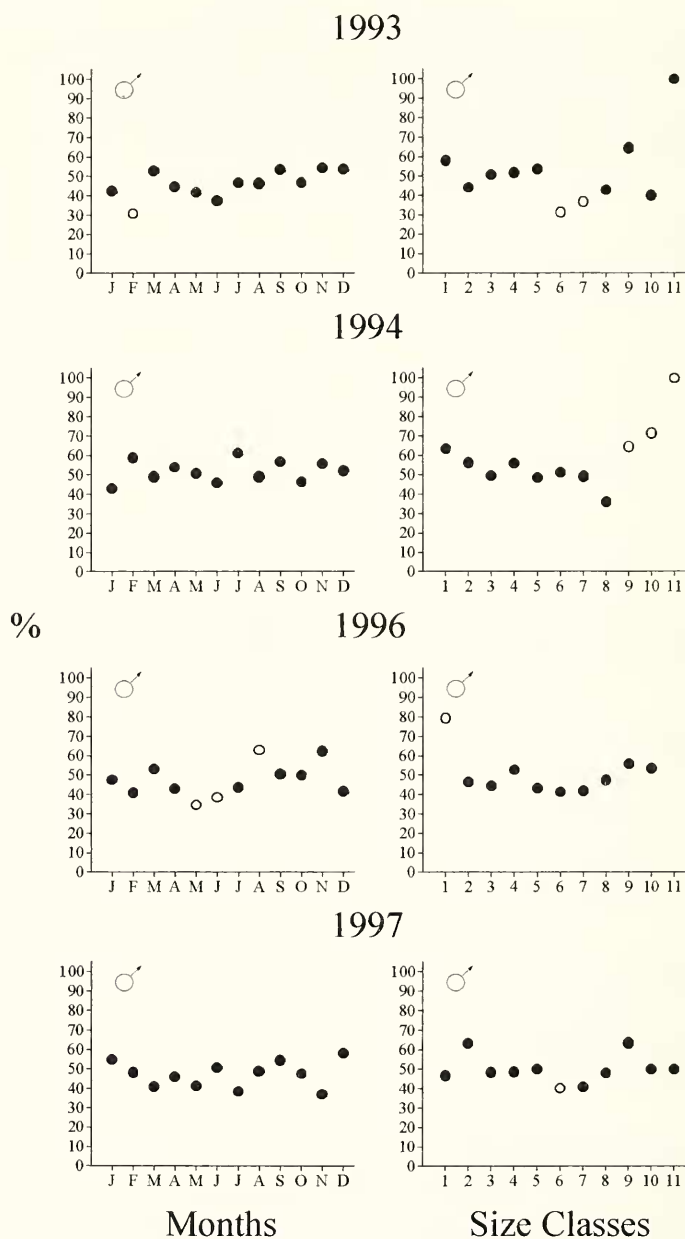


Fig. 1. *Eriphia gonagra*. Male percentage through sampled seasons and along size-classes. Black dots, not significant; white dots, significant ( $p < 0.05$ ).

MANTELATTO **et al.** (1995) present results that support the hypothesis raised by DIAZ & CONDE (1989) that differential growth rate and life span may influence actual relative proportions of sexes.

FLORES & NEGREIROS-FRANSOZO (1999) found out that the shore crab *Pachygrapsus transversus* (Gibbes, 1850) settles as megalopae in poliquete colonies where they molt into juveniles. After the post-settlement phase, they find shelter in rock crevices and forage on the rocky surface. Seemingly, *Plagusia dentipes* De Haan, 1835 also uses the rocky areas after the pelagic zocal phase (TSUCHIDA & WATANABE, 1997). In these cases, unbiased sex ratio estimates are more likely to be obtained because once settled, these species do not migrate to other regions, remaining confined to the area delimited by the rocky shore.

In grapsids living in mangroves or other estuaries, collections may be more difficult depending on the sampling area. OMORI **et al.** (1997) verified that *Helice japonica* Sakai & Yatsuzuca, 1979 and *H. tridens* De Haan, 1835 follow the 1:1 proportion. In other grapsids inhabiting such habitats, deviated proportions have been thought to occur due to their reproductive strategy, habitat partitioning or sampling in a heterogeneous area.

For the Portunidae, departures from the 1:1 ratio favoring males are common (RAZ-GUZMAN **et al.**, 1986; ABELLÓ, 1989; ABELLÓ & MACPHERSON, 1989; SUMPTON, 1990; LUNARDON-BRANCO & BRANCO, 1993; OMORI **et al.**, 1997). These organisms are usually caught by trawling, which provides strongly biased samples due to the fact that females of some swimming crab species migrate to other areas to breed. In *Callinectes danae* Smith, 1869 and *Portunus spinimanus* Latreille, 1819 females outnumber males (LUNARDON-BRANCO & BRANCO, 1993; SANTOS **et al.**, 1995), probably because they are particularly vulnerable to trawling nets when returning to inshore waters after mating in estuaries, as documented for *C. danae*.

From the four bibliographical data of ocypodid species, *Ucides cordatus* (Linnaeus, 1763) and *Uca uruguayensis* Nobili, 1901, which inhabit mangroves and salt marshes respectively, significant departures from the 1:1 proportion were recorded (ALCÂNTARA-FILHO, 1978; SPIVAK **et al.**, 1991). In the later, such differences would be related to that species' reproductive strategy, since SPIVAK **et al.** (1991) discarded differential habitat partitioning and migration. In *Uca pugnax* (Smith, 1870), WOLF **et al.** (1975) suggest that deviations from the 1:1 ratio are due to differential mortality caused by a higher susceptibility of females to predators.

Results obtained by SNOWDEN **et al.** (1991), in the eulittoral crab *Ilyoplax stevensi* (Kemp, 1919) using transect and quadrat methods, show that proportions of sexes in the studied population fall in the 1:1 ratio. This pattern was also verified by TROTT (1998) in *Ocypode gaudichaudii* H. Milne Edwards & Lucas, 1843 in spite of the observed sex-related spatial distribution, whose effect on sampling sex ratio will depend on the area within the intertidal from which samples are taken.

From the data of six xanthid species examined (FURTADO-OGAWA, 1972; SWARTZ, 1976; RAZ-GUZMAN **et al.**, 1986; VANNINI & GHERARDI, 1988; present study), 50% follow the 1:1 expected ratio. *Eriphia gonagra* was collected from a restricted area where migration, sex reversal, differential growth rates and sex-dependent mortality do not apparently occur. However, habitat partitioning does take place, since potential microhabitats as sand reefs built by sabellariid poliquetes are spread over most part of the sampling area. This differential habitat partitioning may contribute to bias in some monthly



samples and in given size-classes in size vs. sex-ratio analysis. Otherwise, lack of suitable sampling size hampers the analysis of significance in certain cases in 1993 and 1994, when 100 % of males in the last size-class correspond to a single examined specimen. Such individuals are often hidden in tight rock crevices which difficulties their collection. Even so, overall ratios are not significantly different from the expected 1:1 proportion.

After examining the obtained data, it can be noticed that collections obtained from trawling provide biased ratios. This may be largely due to the fact that such procedure fails in obtaining representative sampling of the whole distribution area of a given species. In mangrove areas sampling specimens depends on a series of limiting factors, such as activity rhythms, habitat shift through ontogeny and variation of abiotic factors, namely temperature and salinity. When restricted areas can be isolated for sampling, e.g. a rocky shore, a seaweed patch, then obtained proportions usually follow the 1:1 ratio because populations living in these biotopes can be better monitored.

This comparative analysis suggests that overall sex ratio in brachyurans tends to 1:1. Deviations from this may be directly related to the sampling procedure or to the sampling area chosen for analysis. Besides, growth rate, life span, environmental pressure, habitat partitioning, food availability and reproductive strategy may affect sexes in a different extent, thus promoting departures from expected sex proportions along the ontogeny of these organisms.

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